RELEVANT AND IRRELEVANT AUDITORY BACKGROUNDS DURING VISUAL MONITORING

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THESIS

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Relevant and Irrelevant Auditory Backgrounds During Visual Monitoring

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ABSTRACT

The purpose of this study was to determine the effect of three different auditory environments on performance during a simple visual monitoring task. The vigilance task was the detection of an abnormally large deflection of a voltmeter needle making twenty uniform deflections per minute. The length of the watch was sixty minutes, during which thirty-two signals were presented. Twenty-four military officers were used as subjects, eight in each group. A statistical examination of the results did not detect any statistically significant difference between the percentage of signals detected by each of the three groups. There was, however, a significant decline in performance over time.

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I. INTRODUCTION

Vigilance has been defined in many ways: as the ability of men to remain alert, as attention over extended periods of time, and as an observer's readiness to respond to infrequent, low intensity signals occurring at unpredictable temporal intervals. The number of situations and jobs which involve the performance of a vigilance task by man has increased dramatically in the last several decades, and will continue to grow in the foreseeable future. The primary impetus to this growth was provided by the introduction of complex, electrical and mechanical systems in industry and the armed forces. The monitoring of radar scopes and sonar equipment, the observation of items in an assembly line for defects, and watching the various dials and gages of automated equipment are but a few of the possible examples of man's involvement in vigilance tasks. These tasks are boring and monotonous to the average individual but nevertheless, they are frequently vitally important to the successful execution of military and industrial operations.

Since World War II, extensive research has been conducted in the area of human vigilance in an effort to determine man's capabilities as a monitor, the factors which affect his performance, and if possible, ways to predict performance levels. The majority of this research effort has been in the form of experiments designed to test specific hypotheses, but some work has been done to develop theoretical models to explain the experimental results.

In an effort to find ways of improving man's performance during monitoring tasks, some investigation has been made into the use of various types of environmental stimulation. The theoretical basis for this investigation is found in the arousal theory which predicts improved performance levels under external stimulus conditions. The main purpose of this current study was to determine the effect of different auditory environments on performance during a simple visual monitoring task.

II. BACKGROUND

In order to provide the reader with a brief review of the research which has been accomplished to date, pertinent information on several experiments is presented in outline form. All the experiments described involve watchstanding in an environment containing a source of irrelevant audio stimulation.

A. Title: Noise, paced performance and vigilance tasks

Name: Broadbent, D. E.

Display type: Five neon lamps at the corners of an equal-sided pentagon

Sense Mode: Visual

Signal Type: Light

Signal Frequency: Under paced conditions, a signal was presented every second. Under unpaced conditions, a signal was presented immediately after every response.

Independent Variables: Time on watch; paced vs. unpaced conditions of signal presentation; noise (100 db) vs. quiet (70 db) and duration of watch.

Subjects: Forty-seven naval enlisted men divided into four groups.

Response: Subjects were required to touch a contact corresponding to the lighted lamp in a five-choice serial reaction test.

Duration of Watch: 90 minutes and 30 minutes

Performance Measure: Number of correct responses

Results: Under the noise condition, there were increased errors in both paced and unpaced performance.

B. Title: Some effects of noise on visual performance

Name: Broadbent, D. E.

Display Type: The twenty dials task -- twenty dials, 6 inches in diameter arranged to make up three sides of a square, 12 feet to a side, with the subjects occupying the fourth side. The twenty light task -- twenty lights in the same general arrangement as the dials except that they were dispersed from ground level to 4 feet from the ground.

Sense Mode: Visual

Signal Type: Deflection of the dial pointer from a norm position and flashing light.

Signal Intensity: 0.8 inch deflection; 5 ft-L light against a 3 ft-L background.

Signal Duration: Signal lasted until reset by subject.

Signal Frequency: 10/hour

Independent Variables: Noise (100 db) vs. quiet (70 db); time on watch

Subjects: 30 naval ratings, 18 to 30 years of age

Response: Turned on knob under the affected dial upon detecting a signal

Duration of Watch: 90 minutes on five successive days

Performance Measures: "Seens" -- the number of signals detected when the subject was attending to a dial or light when the signal occurred; "founds" -- dials discovered to have the signal without having seen the signal occur; "quick founds" -- the proportion of "founds" responded to in nine seconds or less.

Results: The number of "seens" was unaffected by noise; the number of "founds" was significantly less under noise conditions on the 20-dials test; noise did not affect performance on the 20-lights task.

C. Title: Relationships of intermittent noise, inter-signal interval and skin conductance to vigilance behavior

Name: Dardano, J. F. and Mower, I.

Display Type: Cathode-ray tube light

Sense Mode: Visual

Signal Type: Increase in amplitude of periodically blinking background light

Signal Rate: 60/hour

Independent Variables: Time on watch; noise, intersignal variability; intersignal duration

Subjects: Army enlisted men

Response: Reported signal detections as quickly as possible

Duration of Watch: 180 minutes

Performance Measures: Latency of response; skin conductance levels.

Results: Intermittent noise impaired performance with the low variability schedule, but did not affect performance with the high variability schedule.

D. Title: Experiments on vigilance, performance on a simple vigilance task in noise and in quiet

Name: Jerison, H. J.

Display Type: Mackworth clock test

Sense Mode: Visual

Signal Intensity: Twice the angular distance of regular background jumps

Signal Frequency: 30/hour

Independent Variables: Time on watch; noise (112.5 db) vs. quiet (79 db) conditions

Subjects: 20 paid male undergraduates.

Response: Pressed a switch upon detecting a signal

Duration of Watch: 105 minutes

Performance Measure: Percentage of signals detected

Results: There was no difference between performance in quiet and performance in noise.

E. Title: Effects of noise and fatigue on a complex vigilance task

Name: Jerison, H. J.

Display Type: Three Mackworth clocks

Sense Mode: Visual

Signal Type: Double jump of the clock hand

Signal Intensity: Twice the angular distance of regular background jumps

Signal Frequency: 36, 25 and 21 signals per hour for three different clocks

Independent Variables: Time on watch; noise (114 db) vs. quiet (83 db) working conditions

Subjects: 9 volunteer male undergraduates

Response: Subjects pressed a response switch under the affected clock upon detecting a signal.

Duration of Watch: 120 minutes

Performance Measure: Percentage of signals detected

Results: There was no decrement in performance under the quiet conditions; under the noise condition subjects performed at a lower level than under quiet conditions, and sustained a decrement in percentage of signals detected during the last 1/2 hour of watch.

F. Title: The effect of an external audio signal on vigilance performance and physiological parameters

Name: Marshall, W. S.

Display Type: Voltmeter needle with background painted white and a black needle

Sense Mode: Visual

Signal Type: An increment in the magnitude of the needle deflection

Signal Frequency: 32 signals in a 48-minute watch

Signal Intensity: Regular movement of needle was 40 degrees and the signal was 46 degrees

Independent Variables: Time on watch; presence of audio signal

Subjects: Twelve male military officer graduate students

Response: Pressed a switch upon detection of a signal

Duration of Watch: 48 minutes

Performance Measure: Percentage of signals detected; number of commissive errors

Results: The difference in signals detected due to the external audio stimulus was not significant; the number of commissive errors committed by the subjects was small and no significant analysis could be made of this data.

G. Title: Studies of visual fatigue

Name: McFarland, R. A., Holway, A. N. and Hurvich, L. M.

Display Type: A patch of light

Sense Mode: Visual

Signal Type: Periodic increases in the standard brightness of the light

Independent Variables: Time on watch; interpolated rest (position shift), and interpolated extraneous activity

Response: Subjects continuously judged brightness differences

Duration of Watch: 120 to 480 minutes

Performance Measure: Difference limen between the brightness of a 10,000-photon light and a variable light

Results: Almost any extraneous stimulus such as telephone calls, background conversation, etc., improved DL's to some extent. These improvements were usually short lived.

H. Title: Maintenance of alertness by a loud auditory signal

Name: Pollack, I. and Knaff, P. R.

Display Type: A VU meter with a needle pulsed at 2.0 seconds

Sense Mode: Visual

Signal Type: An increment in the magnitude of the needle deflection

Signal Intensity: A 1.6 db difference between two successive deflections

Signal Duration: 0.3 seconds

Signal Frequency: 48/hour

Independent Variables: Time on watch; working in isolation in a darkened booth vs. working in the company of other subjects in a brightly lighted room, with a radio playing and conversation (except about signals) permitted; and reinforcement conditions, i.e. neutral subjects told to "do the best they can," reward -- extra pay for good performance, and punishment -- blast of a truck horn whenever a signal was missed.

Subjects: Fifteen paid subjects each stood two watches under each experimental condition.

Response: Pressed a button upon detecting a signal

Duration of Watch: 80 minutes

Performance Measure: Percentage of signals detected; latency of response; and number of false detections made

Results: There was no significant difference between performance in the light and dark environments. Punishment was more effective in the dark and reward more effective in the light.

I. Title: Music and other auditory backgrounds during visual monitoring

Name: Poock, G. K. and Wiener, E. L.

Display Type: Voltmeter needle with the background painted black and a white needle

Sense Mode: Visual

Signal Type: An increment in the magnitude of the needle deflection

Signal Frequency: 40 signals in a 75-minute watch

Signal Intensity: Regular movement of the needle was 20 degrees and the signal was 30 degrees

Independent Variables: Time on watch; auditory backgrounds consisting of preferred music, non-preferred music, white noise and conversation between airport tower controllers and pilots

Subjects: 75 male undergraduate students

Response: Pressed a switch upon detection of a signal

Duration of Watch: 75 minutes

Performance Measures: Percentage of signals detected; number of commissive errors

Results: There were significant differences at the .05 level between the group listening to the conversation between pilots and air tower controllers and all other groups except the group listening to the non-preferred music; the audio background had no effect on the number of commissive errors.

J. Title: Extraneous auditory stimulation and visual vigilance

Name: McGrath, J. J.

Display Type: Light appearing in a one-inch square ground glass-covered aperture

Sense Mode: Visual

Signal Type: Increase in brightness in a light

Signal Frequency: 21, 23, 25 and 27 signals per hour

Signal Intensity: The brightness difference discriminable with ninety per cent accuracy by alerted subjects.

Independent Variables: Time on watch; audio backgrounds consisting of white noise and a variety program made up of instrumental music, vocal music, audio portions of television programs and various mechanical noises; time of day and watchstanding practice.

Subjects: 28 Navy enlisted men

Response: Pressed a switch upon detection of a signal

Duration of Watch: 60 minutes

Performance Measures: Percentage of signals detected; number of commissive errors

Results: The improvement in performance under variety conditions was very significant; the audio background did not affect the number of commissive errors.

K. Title: Irrelevant stimulation and vigilance under fast and slow stimulus rates

Name: McGrath, J. J.

Display Type: Light appearing in a one-inch square ground glass-covered aperture

Sense Mode: Visual

Signal Type: Increase in brightness in a light

Signal Frequency: 24 signals per hour

Signal Intensity: The brightness difference discriminable with ninety per cent accuracy by alerted subjects

Independent Variables: Stimulus presentation rate which included a slow rate of 20/min. and a fast rate of 60/min; audio backgrounds consisting of white noise and a variety program made up of instrumental music, vocal music, audio portions of television programs and various mechanical noises

Subjects: 24 Navy enlisted men

Response: Pressed a switch upon detection of a signal

Duration of Watch: 60 minutes

Performance Measure: Percentage of signals detected

Results: There was no significant effect due to the conditions of irrelevant auditory stimulation.

L. Title: Vigilance with background music

Name: Wokoun, W.

Display Type: Translucent piece of plastic about one inch square which could be illuminated from behind with three colors of light -- red, green and yellow

Sense Mode: Visual

Signal Type: Turning on of a light

Signal Frequency: 8 per hour

Independent Variables: Audio backgrounds which included music vs. continuous noise provided by a fan; time on watch

Subjects: 14 males between the ages of 18 and 35

Response: Pressed a switch upon detection of a signal

Duration of Watch: 60 minutes

Performance Measure: Reaction time

Results: There was no significant effect due to auditory background.

III. OBJECTIVE

The results of experimentation involving the use of different auditory backgrounds during visual monitoring tasks indicate that the effect on performance is dependent upon the type of audio background used. It has been shown, for example, that environmental noise has reduced detection efficiency. Studies by Wokoun (1963), Poock and Wiener (1966) indicate that while subjects enjoy listening to music during vigilance tasks, their performance level is not affected by the music. The use of variety programs consisting of vocal and instrumental music, portions of television and radio programs, mechanical noises, etc., in experiments by McFarland, Holway and Hurvich (1942), Pollack and Knaff (1958), and McGrath (1959), indicate that this type of audio background either has no effect, or it improves performance.

All of the audio backgrounds mentioned above have one thing in common, they have nothing to do at all with the task being performed. These irrelevant backgrounds can be contrasted with relevant backgrounds which in some manner relate to monitoring tasks. Poock and Wiener used what can be described as a relevant background in their study. In that experiment the group listening to a conversation between pilots and air controllers who were engaged in a realistic monitoring task performed better than other groups listening to music and white noise.

This thesis in a sense is an extension of the work of Poock and Wiener. It is designed to test the effect of a relevant audio background as compared to two different irrelevant backgrounds. The relevant background consisted of a conversation between the astronauts on the Apollo XII mission and personnel in ground control at Houston, Texas. Instrumental music and white noise were used as the other two backgrounds.

IV. METHOD

A. EXPERIMENTAL DESIGN

The monitoring task consisted of the detection of an abnormally large deflection of a voltmeter needle. These deflections occurred at the relatively slow rate of 20 deflections per minute. The signal schedule consisted of 32 signals appearing at random intervals in the 60-minute watch with the restrictions that 8 signals appeared in each 15-minute period, and that the minimum inter-signal interval was 24 seconds. A table of random units was utilized to determine the exact times at which signals occurred.

The voltmeter needle moved 20 degrees from its resting position during a normal deflection but for a signal the needle moved 5 degrees further for a total deflection of 25 degrees from the rest position. After each rightward deflection, the voltmeter needle returned to the rest position at the left side of the meter. In the rest position the voltmeter needle was 40 degrees above the horizontal. The magnitude of the deflection for both normal stimuli and signals was determined by preliminary experimentation in which it was determined that the setting chosen produced a vigilance decrement over time. A response within 3.0 seconds after presentation of a signal was considered a detection; all other responses were scored as commissive errors or false alarms.

Twenty-four subjects were used in the experiment which lasted 60 minutes, and each subject experienced the same signal schedule.

Three auditory backgrounds were used in this study: white noise (WN), instrumental music (IM), and portions of conversation between the astronauts on the Apollo XII mission and personnel in ground control at Houston, Texas (C). Eight subjects were randomly assigned to each of the 3 audio backgrounds so that each of the 24 subjects experienced only one level of this experimental factor. The subjects received their appropriate auditory background over earphones. The music was a tape recorded 60-minute program of instrumental selections provided by the Muzak Corporation of New York City (Muzak Program Number J211). The Apollo XII technical air-to-ground voice transcription was a tape recording provided by the National Aeronautics and Space Administration. The tape used was a complete recording of all conversation between ground control and the astronauts during the first 116 minutes of the Apollo XII mission. The 116 minutes of real time were condensed to 60 minutes for use in the experiment. This was accomplished by reducing all real-time periods of silence which were greater than 2 minutes duration to exactly 2 minutes.

In addition to the audio backgrounds, the other independent variable used in this study was time on watch. For the purposes of this study, the 60-minute watch was broken down into four consecutive 15-minute intervals.

The experiment can be described as a two-factor experiment, audio background and time on watch, in which there are repeated measures on the time on watch factor. The repeated measures refer to the fact that

all 24 subjects are observed under the 4 levels of the time on watch factor. This design is also referred to as a three-factor partially hierarchal design. The experimental design is represented schematically in Figure 1.

	TIME PERIOD IN MINUTES			
	I (0-15)	II (16-30)	III (31-45)	IV (46-60)
White Noise	Group 1*	Group 1	Group 1	Group 1
Instrumental Music	Group 2*	Group 2	Group 2	Group 2
Conversation	Group 3*	Group 3	Group 3	Group 3

* Groups 1, 2 and 3 each contained 8 subjects.

FIGURE 1. EXPERIMENTAL DESIGN

The percentage of signals detected and the number of commissive errors were used as dependent variables in this study.

During the watch, each subject was permitted to smoke and drink non-alcoholic beverages. This was allowed in an effort to create a relaxed atmosphere for the watch and because it is permitted in many real-life vigilance tasks. The subjects were not informed of the purpose of the study. They were told that the auditory backgrounds they heard in the earphones were designed to drown out other noises in the building. The exact length of the watch was also unknown to the subjects. They were told, however, that approximately 75 minutes of their time would be needed for instruction, a practice run, and the actual run of the experiment.

B. SUBJECTS

Twenty-four military officer students at the United States Naval Postgraduate School were randomly selected as subjects in the experiment. The ages of the subjects ranged from 26 to 37 years of age. Those subjects who normally wore glasses were permitted to do so for the experiment. Each subject was tested once, and none had served in previous monitoring studies.

C. APPARATUS

The voltmeter used in the experiment was mounted on the center of a 24-inch by 48-inch piece of 1/2-inch plywood which had been painted white. The dimensions of the voltmeter were approximately 5 inches by 5 inches. The needle was painted black and the background face of the voltmeter was solid white. The piece of plywood was located on a table in such a position that the voltmeter was vertical, 30 inches from the seated subject, and approximately 6 inches below eye level. The table was located in the corner of an air-conditioned room. A plywood partition placed at the side of the table prevented a subject from viewing other parts of the room during the experiment.

A punched paper tape was fed through a paper tape reader to produce an electrical pulse which resulted in the deflection of the needle on the voltmeter for both regular stimuli and signal stimuli.

A silent button-type response switch located on the table was used by subjects to report detection of a signal.

A 6-channel recorder was utilized to record the signals presented to subjects and their responses.

A Wollensack magnetic tape recorder with earphones was used to provide the instrumental music and conversation audio backgrounds for Groups 2 and 3 respectively.

White noise at a 30db level was sent through earphones for Group I subjects.

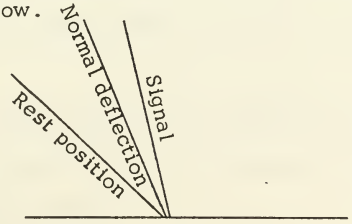
D. PROCEDURE

Prior to the arrival of each subject, the electronic equipment used in the experiment was turned on and permitted to warm up. Each item was then checked to insure that it was in proper working order. All settings were examined to verify that consistent experimental conditions were being maintained.

When the subject entered the laboratory, he was asked to remove his watch and to take a seat at the table where he would be tested. The subject was then instructed to carefully read the following instructions:

This experiment is designed to test your ability to detect infrequent, randomly spaced, low intensity signals. This task is similar to that performed by a radar operator. Your job during the experiment is to detect an abnormally large deflection of a voltmeter needle which will make approximately 20 deflections per minute.

An accurate pictorial representation of the rest position, normal deflection and signal is given below.



You are to indicate detection of a signal by pressing the response button provided at the desk. You should respond to a signal as soon after detection as possible. There are two types of errors which you want to avoid making:

a. commissive error or false alarm -- when you respond in the absence of a signal.
b. ommissive error -- you fail to respond to a signal.

During the course of the experiment, you will wear earphones from which you will hear an auditory background designed to drown out other noises in the building.

Prior to the actual experiment, there will be a 2-minute "dry run" in which 30 normal deflections and 10 signals will be presented. Deflections #4, 8, 12, ... 32 will be signals. They are presented in this definite pattern in an effort to fix clearly in your mind the difference between a signal and a normal deflection.

Unlike the 2-minute "dry run," the signals during the actual experiment will occur very infrequently and will be randomly spaced over time. During the course of the experiment, you are requested to keep your eyes behind the red line on the desk.

QUESTIONS ?

Note: The red line was designed to keep the subjects far enough from the display to prohibit use of dust spots on the white face of the voltmeter as reference points for signal detection.

After reading the instructions, each subject was permitted to ask questions to insure that he completely understood what was expected of him during his watch.

After the subject was instructed, a practice run of two-minutes duration was conducted during which 10 signals and 30 normal deflections were presented in a definite pattern. The subjects did not wear the earphones during the practice run.

At the conclusion of the practice run the subject put on the earphones, adjusted them to a comfortable position and the 60-minute vigilance task was then begun.

After the watch was completed, the subject was briefed on his performance and instructed not to discuss the experiment with other students at the Naval Postgraduate School.

V. RESULTS

A. PERCENTAGE OF SIGNALS DETECTED

Figure 2 appears to show a decrement in detection performance by all subjects 15 minutes after the watch started. During the last 45 minutes of the watch, the performance level remained essentially constant.

The performance decrement for the conversation group was less than that of the other 2 groups. The results shown in Figure 2 also indicate that the group listening to the conversation audio background performed better than the other 2 groups. There appeared to be little difference between the performance levels of the music and white noise groups.

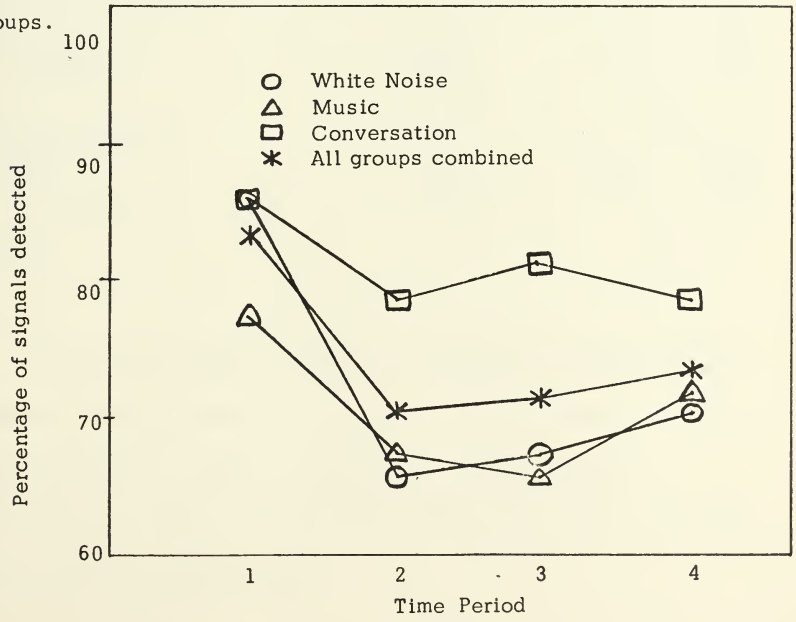


FIGURE 2. PERCENTAGE OF SIGNALS DETECTED PER 15-MINUTE PERIOD

Table I shows the results obtained from an analysis of variance procedure designed for a two-factor experiment with repeated measures on one factor (Winer, 1962). Prior to performing the analysis of variance on the data, an arcsin transformation was performed because the percentage of signals detected, by definition, had a maximum value of one. This transformation, recommended by Winer (1962) tended to stabilize the variances.

TABLE I.

ANALYSIS OF VARIANCE ON PERCENTAGE OF SIGNALS DETECTED

Source of Variance	Degrees of Freedom	Mean Square	"F" Ratio	Probability Level (less than)
Between subjects	23			
Groups (G)	2	.8335	.7377	N.S.
Error (Between)	21	1.1298		
Within subjects	72			
Time Periods (T)	3	.635	3.07	.05
GXT	6	.1690	.7945	N.S.
Error (Within)	63	.2127		
TOTAL	95			

The results of Table I show that the difference between the percentage of signals detected by each of the three groups was not statistically significant. There was, however, a significant decline in performance over time. The interaction between the time periods and groups was also not significant.

B. COMMISSIVE ERRORS

Table II shows the total number of commissive errors by group and time period. In an effort to diminish the effect of a large number of commissive errors contributed by a few subjects, an extension of the median test (Siegel, 1956) was used to detect any difference between groups. The results of this test were inconclusive. This occurred because there were unacceptably small expected frequencies in the cells of the contingency table set up as part of the computational procedures involved in the extension of the median test.

TABLE II.

COMMISSIVE ERRORS BY GROUP AND TIME PERIOD

Group	Period				Total
	1	2	3	4	
W.N.	103	19	13	11	146
I.M.	34	2	0	3	39
C	54	18	8	9	89
TOTAL	191	39	21	23	274

VI. DISCUSSION

The results of the analysis of variance showed that there was no statistically significant difference between the percentage of signals detected for the 3 groups. There are, of course, two possible explanations for this; the three samples do, in fact, come from the same population; or the statistical technique employed to analyze the data was not sufficiently powerful to detect a true difference. In this particular study, the main effects of the audio background factor are completely confounded with the differences between groups (Winer, 1962). In addition to this, the small sample size and the magnitude of the individual differences in vigilance performance all contribute to a significant reduction in the power of the test. Thus, the failure of the analysis of variance test to validate the apparent superior performance of the conversation group in this experiment could be attributed to the reduced power of the test.

One of the main contemporary theories of vigilance is the arousal theory. Hebb (1958) asserted that "the normal variety of sensory stimulation has the function of maintaining arousal: the alertness, responsiveness, or vigilance of the waking subject. When the stimulation is made drastically monotonous, mental function is significantly affected." Deese (1955) summarized the arousal theory when he said "the maintenance of a given level of vigilance in an observer depends to some extent upon stimulus events extrinsic to the observer." The majority of the

studies designed to test the arousal theory have utilized novel, irrelevant, backgrounds to increase the total variability of the stimulus situation. The typical hypothesis used in these experiments said "watchstanders will detect a greater percentage of signals when a variety of stimulation is present in the environment than in the absence of such variety, even though the increased variability has no relevance for the vigilance task being performed." A search of the literature indicates that little experimentation has been done utilizing novel, relevant backgrounds during vigilance tasks. Poock and Wiener in 1966 reported the results of an experiment designed to explore the use of background music and other auditory backgrounds to enhance performance on a monotonous, visual, monitoring task. The "other" auditory backgrounds used in the experiment were white noise and a recording of the conversation between pilots flying in the Miami, Florida area and controllers at Miami International Airport. The results of this experiment showed that the performance of the group listening to the conversation was superior to all the other groups. Poock and Wiener commented that "the superior performance of the conversation group is not easy to explain, as it is difficult to state just what this auditory background represented, though it certainly is safe to say that it was for this subject population, a fairly novel and interesting background." In the experiment which is the subject of this paper, the group listening to conversation in the Apollo XII mission performed better, though not significantly better, than the groups listening to white noise or music. Perhaps the superior

performance of the groups listening to conversation in both experiments can be partially explained by the fact that in addition to being novel and interesting, these conversations were also relevant to the vigilance task being performed. In both cases the participants in the conversation were talking about performance of "real world" vigilance tasks which were similar to the task being performed by the subjects of the experiment under laboratory conditions. Thus, in addition to providing a variety of stimulation, the conversation may have provided some motivation for the subjects who were performing their task in the rather sterile, unmotivating atmosphere of a laboratory.

In conclusion, it would seem that further investigation into the use of relevant backgrounds during vigilance tasks might be profitably studied.

APPENDIX A. SUMMARY OF OBSERVED DATA

1. Percentage of Signals Detected

GROUP	SUBJECT	Time Periods in Minutes I (0-15)	II (16-30)	III (31-45)	IV (46-60)
	1.	1.000	.875	.625	.500
	2.	.625	.375	.625	.375
	3.	1.000	.875	.875	.250
White	4.	.625	.375	.500	.875
Noise	5.	.875	.750	1.000	1.000
	6.	1.000	.500	.500	.750
	7.	.875	.750	.750	.875
	8.	.875	.750	.500	1.000
	9.	1.000	1.000	.875	1.000
	10.	1.000	1.000	.750	1.000
	11.	.875	1.000	.875	.875
Instrumental	12.	.750	.625	.625	.375
Music	13.	.250	.125	.375	.500
	14.	.750	.125	.250	.500
	15.	.625	.875	.625	.750
	16.	.875	.625	.875	.750
	17.	1.000	.875	.875	1.000
	18.	.875	.750	.625	.500
	19.	.625	.625	.625	.500
Conversation	20.	1.000	.875	1.000	.875
	21.	1.000	1.000	1.000	.875
	22.	.500	.500	.375	.875
	23.	.875	.625	1.000	.750
	24.	1.000	1.000	1.000	.875

2. Number of Commissive Errors

GROUP	SUBJECT	Time Periods in Minutes I (0-15)	II (16-30)	III (31-45)	IV (46-60)
	1.	0	0	0	0
	2.	5	2	0	0
	3.	38	1	0	1
White	4.	1	0	0	0
Noise	5.	24	12	9	10
	6.	8	0	0	0
	7.	23	3	4	0
	8.	4	1	0	0
	9.	19	0	0	0
	10.	1	0	0	0
	11.	6	1	0	0
Instrumental	12.	1	0	0	0
Music	13.	0	0	0	0
	14.	3	0	0	1
	15.	3	1	0	0
	16.	1	0	0	2
	17.	3	0	2	1
	18.	1	1	2	1
	19.	21	12	1	6
Conversation	20.	12	0	1	0
	21.	13	3	2	1
	22.	0	0	0	0
	23.	1	2	0	0
	24.	3	0	0	0

BIBLIOGRAPHY

Broadbent, D. E., "Noise, Paced Performance, and Vigilance Tasks," British Journal of Psychology, v. 44, p. 295-303, 1953.

Broadbent, D. E., "Some Effects of Noise on Visual Performance," Quarterly Journal of Experimental Psychology, v. 6, p. 1-5, 1954.

Buckner, D. N. and McGrath, J. J., Vigilance: A Symposium, McGraw-Hill, 1963.

Dardano, J. F. and Mower, I., "Relationships of Intermittent Noise, Intersignal Interval, and Skin Conductance to Vigilance Behavior," Human Engineering Laboratory Technical Memorandum No. 7-59, 1959.

Jerison, H. J., "Performance on a Simple Vigilance Task in Noise and Quiet," Journal of the Acoustical Society of America, v. 29, p. 1163-1165, 1957.

Jerison, H. J. and Wing, S., "Effects of Noise and Fatigue on a Complex Vigilance Task," WADC Technical Report No. 57-14, 1957.

Marshall, W. S., The Effect of An External Audio Signal on Vigilance Performance and Physiological Parameters, M.S. Thesis, Naval Postgraduate School, Monterey, California, April 1970.

McFarland, R. A., Holway, A. N. and Hurvich, L. M., "Studies of Visual Fatigue," Harvard Graduate School of Business Administration Report, 1942.

McGrath, J. J., "The Effect of Irrelevant Environmental Stimulation on Vigilance Performance," Human Factor Problems in ASW, Technical Report No. 6, 1960.

McGrath, J. J. and Hatcher, J. F., "Irrelevant Stimulation and Vigilance Under Fast and Slow Stimulus Rates," Human Factor Problems in ASW, Technical Report No. 7, 1961.

McGrath, J. J., Harabedian, A. and Buckner, D. N., "Review and Critique of the Literature on Vigilance Performance," Human Factor Problems in ASW, Technical Report No. 1, 1959.

Pollack, I. and Knaff, P. R., "Maintenance of Alertness By A Loud Auditory Signal," Journal of the Acoustical Society of America, v. 30, p. 1013-1016, 1958.

Poock, G. K. and Wiener, E. L., "Music and Other Auditory Backgrounds During Visual Monitoring," The Journal of Industrial Engineering, v. 17, p. 318-323, June 1966.

Siegel, S., Nonparametric Statistics, McGraw-Hill, 1956.

Winer, B. J., Statistical Principles in Experimental Design, McGraw-Hill, 1962.

Wokoun, W., "Vigilance with Background Music," U. S. Army Human Engineering Laboratories, Technical Memorandum No. 16-33, 1963.

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13. ABSTRACT

The purpose of this study was to determine the effect of three different auditory environments on performance during a simple visual monitoring task. The vigilance task was the detection of an abnormally large deflection of a voltmeter needle making twenty uniform deflections per minute. The length of the watch was sixty minutes, during which thirty-two signals were presented. Twenty-four military officers were used as subjects, eight in each group. A statistical examination of the results did not detect any statistically significant difference between the percentage of signals detected by each of the three groups. There was, however, a significant decline in performance over time.

KEY WORDS	LINK A		LINK B		LINK C	
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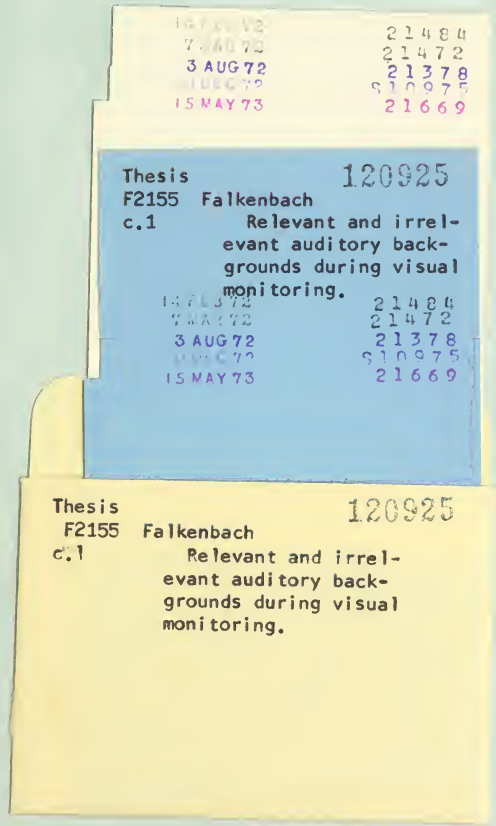

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